Understanding Electric Machines with S.W.I.M.

Steve Mann, Powertrenography™, Moveillance™, and Machintegrity™ Project, MannLab™ Shenzhen/Xiamen, mannlab.com

***Abstract*—The Machintegrity™ Project aims to make machines self-revealing and thus end the hypocrisy of surveillance (one-sided watching) inherent in A.I., machine learning, and Internet of Things. As a simple example, we present a new way of researching, understanding, and teaching fundamentals of electric machines by way of one or more rotary S.W.I.M.s (Sequential Wave Imprinting Machines), making visible the otherwise hidden rotating magnetic fields inside electric motors and generators.**

I. INTRODUCTION AND CONTEXT

Machine Intelligence surrounds us and watches us while often revealing little about itself. Self-driving cars run on secret algorithms. In "smart cities" and "smart buildings" we're watched by thousands of cameras. Yet establishments often prohibit us from taking pictures. They say this is "to protect the privacy of other patrons". This kind of "privacy", where authorities can watch you but you can't watch them or each other, is just another form of information asymmetry in the social contract. **This kind of privacy is surveillance (hypocrisy)**.

Undersight, also known as "sousveillance" (from the French word "sous" meaning "under", and "veillance" meaning "watching"), is necessary to restore integrity to the hypocritical world that would otherwise have only oversight (surveillance). While many systems like autonomous vehicles are built with oversight from the authorities, sousveillant machines are easily audited by end users. Smart technology makes us stupid, or is at least optimized for stupidity. **So intelligence is a disability. The duty to accommodate this disability can be fulfilled with sousveillant systems**.

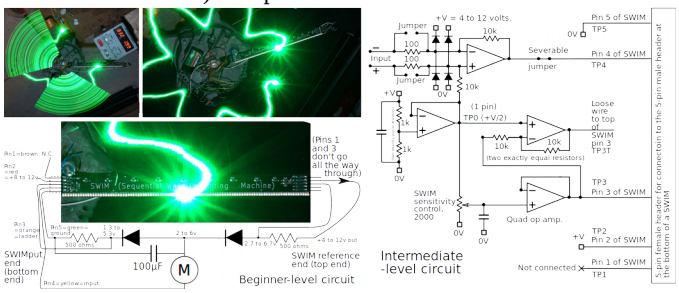
Consider the automobile: each car should be photographed using metaveillography to reveal its sensory capacity. Manufactures should provide this metaveillograph, together with a metaveillogrammetric database, to open themselves up to scrutiny by end customers, not just governments! Moroever, judges and juries would welcome photographic evidence of the proper functioning of machines and their sensors. I proffer the term "**Moveillance™**" to describe sensing of or by motors, akin to the world "motel" which means "motor hotel", or "motown" which means "motor town" ("motor city", i.e. Detroit). In this paper I show a very simple example of this philosophy, based on the SWIM (Sequential Wave Imprinting Machine), a device I invented in the early 1970s to see and understand electromagnetic waves, or sound waves, or metaveillance, by direct observation [2].

II. METHODOLOGY

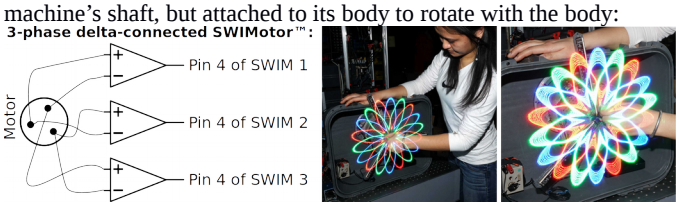
The proposed method for developing a deeper understanding of electric machines (motors or generators) is to mount the shaft of the machine to a fixed object and allow its entire body to rotate, together with one or more SWIMs attached to its body. For example, with a three-phase motor, three SWIMs are mounted at 120 degree angles so that they can spin with the machine's body, while showing the electricity (voltage or amperage), i.e. its rotating magnetic field. Because the body of the machine is rotating together with the rotating magnetic field, the relative motion is canceled. To understand this effect, imagine you were an ant standing on the shaft of a motor as it spins. You would rotate together with the rotating magnetic field, and thus, from your perspective, the rotating magnetic field would appear stationary. Since the shaft of the motor is fixed to an object in the room, and its body is turning, we can regard the situation as if the entire room were spinning with the motor's shaft, and therefore a person standing in the room observes the situation in coordinates in which the speed of magnetic field rotation is exactly zero.

III. RESULTS AND DISCUSSION

For the study a machine, we constructed a 100-LED SWIM to attach to its body. The array is connected to one of the machine's "stator" coils while the role of rotor and stator are reversed (i.e. the "stator" spins with the SWIM, while the "rotor" remains fixed in a vice on a workbench). See pictures below + circuit to teach students:

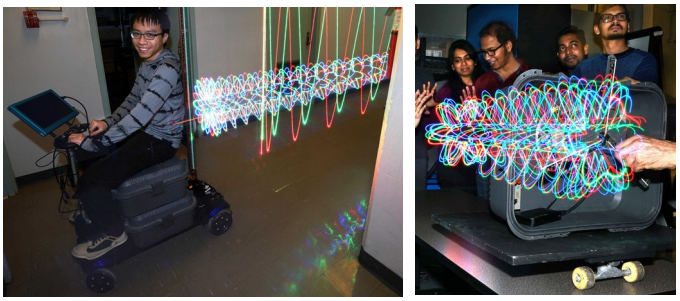


For the study of a 3-phase 12-pole Lundell alternator, we constructed three SWIMs, one made from 100 red LEDs, another from 100 green LEDs, and a third SWIM made from 100 blue LEDs. We mounted these at 120 degree angles on a flat surface, perpendicular to the machine's shaft, but attached to its body to rotate with the body:



Left: wiring for students to replicate. Center: Interactive SWIM. Right: growing and decaying magnetic field.

This gives us a new way to see and photograph electric machines in actual use-cases, e.g. electric vehicle powertrain:



One-person mobility scooter equipped with SWIMs to show the powertrain in time-evolving motor-centric coordinates.

Thanks Diego, Kyle, Pete, Mike, and many others working with us.

REFERENCES

[1] Duffy, A., et al. "The feature selective validation (FSV) method", IEEE EMC2005, Vol. 1, pages 272-277.

[2] Mann, S. Phenomenological Augmented Reality with the Sequential Wave Imprinting Machine (SWIM), IEEE GEM 2018, pages 220-227, Galway, Ireland.